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AN APPRAISAL OF AIR POLLUTION IN SPARTANBURG, SOUTH CAROLINA

G. B. Welsh

Public Health Service
Washington, D. C.

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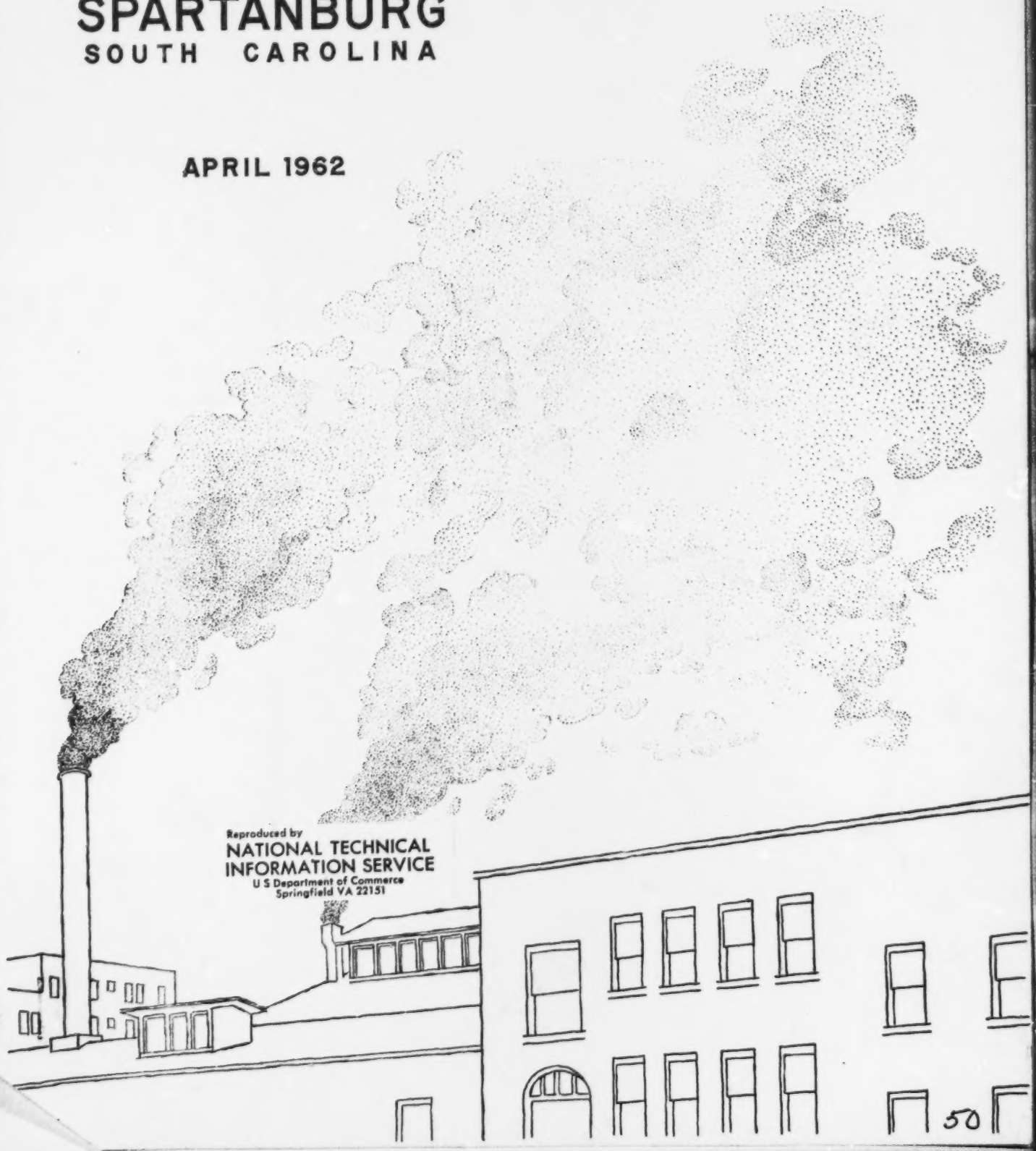
APRIL 1962



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AN APPRAISAL OF AIR POLLUTION

IN

SPARTANBURG, SOUTH CAROLINA

G. B. Welsh
Sanitary Engineer
Division of Air Pollution
Public Health Service
U.S. Department of Health, Education, and Welfare

Details of illustrations in this document may be better studied on microfiche.

A Cooperative Study
by the City of Spartanburg,
South Carolina, the South Carolina
State Board of Health and the Public
Health Service
U.S. Department of Health, Education, and Welfare
April, 1962

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SUMMARY

At the request of the City of Spartanburg and the South Carolina State Board of Health, an appraisal of factors relating to the air pollution problem in Spartanburg, South Carolina, was undertaken by the Division of Air Pollution of the Public Health Service. The purpose of this appraisal was to determine the general nature and extent of the air pollution problem and to develop general recommendations for activities to meet present and future air pollution problems in Spartanburg.

This report is based on data obtained from existing information, brief inspection visits, and a seven-day continuous air sampling study. In view of these limitations this report must be considered only as a preliminary appraisal of the air pollution problem in Spartanburg.

During the period, 1950 to 1960, the population of Spartanburg increased approximately 20 percent. This growth trend, which is expected to continue, favors higher pollution levels in the future because increasing population is generally accompanied by an increase in air pollution emissions.

Local meteorological factors intensify the air pollution problem in Spartanburg. During periods of adverse meteorological conditions air pollutants may be concentrated in the business and residential areas of the city. The southeastern portion of the United States, east of the Appalachians, which includes the Spartanburg area, is subjected to a very high frequency

of low level inversions and stagnating air masses. Both of these conditions contribute to accumulation of air pollution in the Spartanburg area, especially during the months of the year when space heating requirements are greatest.

The atmospheric pollutants of primary concern are due to the combustion of fuels for space heating and power generation in connection with residential, commercial, and industrial usages. Pollutants of secondary concern include odors, gases, solvent vapors, and dusts emitted from fertilizer manufacture, animal feed production, dry cleaning plants, paint manufacture, and the storage and handling of gasoline. In addition, emissions from motor vehicles are significant pollutants to be considered.

While public complaints have been primarily directed at industrial sources of air pollution there are many domestic and commercial sources which add to the complexity and magnitude of the problem. Reduced visiblity is one apparent indication of the air pollution problem in Spartanburg.

The seven-day continuous air sampling study indicated that air pollution levels in Spartanburg could reach significant proportions under adverse weather conditions. Smoke and suspended particulate levels were found comparatively high, when considered in the light of good atmospheric dispersion conditions encountered during the study period.

Reduced visibility in Spartanburg is an indication that combustion of fuels for heating and power generation are significant contributors to the air pollution problem. The levels of gaseous pollutants found during the study are indicative of the unstable, (favorable weather for air pollution dispersal), meteorological situation that existed during most of the study period. However, under adverse meteorological conditions, (low wind speed and low level temperature inversion) the gaseous pollutant levels no doubt would be several times higher than those found during the study period. In fact, they could reach significant levels, contributing to reduced visibility, excessive soiling of clothing and buildings, vegetation damage, and eye, nose and throat irritation.

RECOMMENDATIONS

On the basis of this appraisal and a general knowledge of air pollution, the following recommendations are made to the City of Spartanburg:

1. A modest air pollution control program should be established in the City of Spartanburg. In the beginning this program may require the full-time services of one competent individual.
2. A minimal air pollution ordinance should be enacted. This ordinance should include provisions that:
    a) Prohibit the discharge of smoke darker

than Ringlemann No. 2, or of such opacity as to obscure an observer's view to a degree equal to or greater than smoke darker than Ringlemann No. 2.

b) Prohibit the discharge of other air contaminants or materials which cause injury, annoyance, or nuisance, or which endanger the health, safety, or comfort of the public.

c) Require the review of plans and the issuance of permits for the construction, installation, remodeling, or major alteration of any fuel burning equipment, device, or process that produces air pollutants. Single family or multi-family residences of four or less units and certain other gas or small oil fired units should be exempted from these requirements.

d) Establish a three or five member Air Pollution Technical Advisory Board to review, advise, and recommend to the City Council the appropriate means for the control of air pollution.

3. The air pollution control program should include:

a) Air quality monitoring, on a modest scale, primarily for suspended particulate material as indicated by the high volume filter paper sampler or the AISI Tape Sampler. Data provided by the monitoring program would more fully delineate the nature and extent of the air pollution problem.

b) An inventory of air pollution sources to more fully define the causes of the air pollution problem.

c) Routine observations and inspections for the purpose of finding and bringing about control of dense smoke and other air pollution emissions.

d) Investigation of air pollution sources that are causing complaints and nuisances and the initiation of abatement measures where indicated.

e) Plan, review and permit issuance for new fuel burning installations, industrial processes and certain commercial operations.

f) An educational program for fuel burning equipment operators to assure that proper firing practices are followed to obtain good fuel economy

and produce less smoke, and an educational activity to disseminate information to the general public about the nature and effects and means for control of air pollution in Spartanburg.

4. The Spartanburg zoning ordinances and regulations should be reviewed to assure that they are consistent with the objectives of the air pollution control program and cooperative efforts should be undertaken with the other legal jurisdictions to assure that appropriate zoning requirements are applicable to the areas adjacent to the city.

5. Until the air pollution problem can be approached on a metropolitan area basis, control of sources outside the city that contribute to the Spartanburg problem should be accomplished by a cooperative program involving the appropriate legal jurisdictions.

AN APPRAISAL OF AIR POLLUTION IN SPARTANBURG, SOUTH CAROLINA

INTRODUCTION

Background

Spartanburg is located in the fertile, rolling Piedmont Section of South Carolina among the foothills of the Blue Ridge Mountains. It is the seat of Spartanburg County and serves as a regional shopping center for most of the county, even though it is surrounded by several prosperous suburban communities.

For years there have been complaints by the public about smoke, odors, and reduced visibility in Spartanburg. As a result of these continuing complaints, the mayor, in early 1961, appointed a five member citizens committee to study the air pollution situation. This committee was asked to define the nature and extent of the air pollution problem and outline appropriate steps to be taken by the city administration to alleviate the air pollution problem. This resulted in a request, through the South Carolina State Board of Health, to the Public Health Service Regional Office in Atlanta for technical assistance in appraising the air pollution problem in Spartanburg.

Purpose and Scope:

The purpose of the study was to make a preliminary general evaluation of the air pollution problem and to outline general recommendations

for the guidance of local officials in meeting existing and future air pollution problems.

The scope of the study was limited to consideration of various factors affecting air pollution levels and a review of those activities which contribute pollution to the community atmosphere. In addition, a seven-day air pollution measurement study was conducted to obtain an initial indication of gaseous and particulate pollution levels and to help define the nature and extent of air pollution in Spartanburg. In view of the limited scope of work done, this report should be considered a preliminary appraisal of air pollution problems in the Spartanburg area.

Conduct of the Survey

The Spartanburg Air Pollution Committee collected the background data, made arrangements for plant visits, and provided valuable support to the conduct of this survey.

An engineer from the Technical Assistance Branch, Division of Air Pollution, Public Health Service, conducted the short-term sampling study, reviewed available information, inspected certain industrial installations, and prepared this report. Valuable cooperation and assistance were provided by the Spartanburg City Manager, the City Building Inspection Department, Spartanburg City- County Health Department, the South Carolina State Board of Health, and the Public Health Service Regional

Office in Atlanta. Support in doing chemical work for the air sampling study was provided by Wofford College. Meteorological data and interpretations were provided by the U. S. Weather Bureau staff at Spartanburg Memorial Airport.

GENERAL FACTORS AFFECTING AIR POLLUTION

The intensity of air pollution in Spartanburg is directly related to the quantity, type, and rate of discharge of pollutants to the atmosphere and the ability of the atmosphere to disperse these pollutants. The general factors to be considered are population, characteristics of industry and employment, and land use. All of these affect the nature and magnitude of the community air pollution problem.

Population

Daily activities of the people of Spartanburg are responsible for the emission of certain air pollutants to the atmosphere. Activities such as combustion of fuels for space and water heating, cooking, transportation, and industrial processes contribute a significant amount of pollution. The amount of air pollution attributable to any one individual may be small, but collectively, total emissions may reach significant proportions. Population estimates are an index of future pollution levels, since a population increase is generally accompanied by an increase in pollution emissions.

In 1950, the population of Spartanburg was 36,795; the 1960 census figures indicate a population of 44,352.[1/] Approximately 20,000 people live in the suburban fringe areas of Spartanburg. This indicates a total population of about 64,000 people for the urbanized area of Spartanburg.

The City of Spartanburg experienced a 20 percent population growth during the period 1950 to 1960. During the same period of time the total growth in Spartanburg County was approximately 4 percent (150,349 in 1950 and 156,830 in 1960). In view of the anticipated expansion of industrial and research activities in the Spartanburg area, the population will probably continue to increase in the future. Therefore, air pollutants released to the atmosphere must also be expected to increase unless adequate control measures are instituted.

Characteristics of Industry and Employment

Spartanburg is situated in the very heart of the great Southern textile industry. There are more than 45 textile mills in Spartanburg County operating over 1,000,000 spindles and over 25,000 looms. Although the textile industry predominates, a diversification is shown by the manufacture of bags, fertilizer, paper boxes, machinery, timber products and foundry products. The 180 manufacturing plants in Spartanburg County employ about 26,000 people. Approximately 20,000 of these people are

directly associated with the textile industry.[2/]

Agriculture is another large scale industry in Spartanburg County. Because of its location in a region of fertile farm lands with a fine climate for crops, the agricultural products are very diversified but primarily consist of peaches and cotton. Spartanburg is known as the "fresh peach capital of the world," producing and shipping more than 4,000 carloads of peaches each year. Cotton is another important agricultural product with production being more than 8,000 bales per year. Livestock is rapidly becoming important in this area along with such products as grapes, melons, corn and other grains.

Land Use

Most of the heavy industry within the city limits is located convenient to rail and highway transportation. Light industry and service trade industries are generally dispersed throughout the area.

In recent years, residential development has been principally around the periphery of the city. This has resulted in some intermingling of residential and industrial areas, a practice which promotes the occurrence of neighborhood air pollution problems. It is anticipated that future residential and light industrial expansion will be continued around the city periphery.

Zoning plans within Spartanburg are generally being followed. However, it does appear that some intermingling of industrial and residential usages are being permitted and this could be reduced by using mutually exclusive type zoning requirements. In addition, developments in the suburban fringe areas tend to intermingle some industrial and residential areas, proper zoning requirements would minimize this problem. If the air pollution problem in the Spartanburg area is to be properly controlled, the land use pattern must be regulated without regard to city and county boundaries. This may require a cooperative approach by the city and the county. A land use pattern that permits the intermingling of industrial and residential areas promotes the occurrence of air pollution problems.

DISPERSION OF POLLUTANTS

Topography

Spartanburg is located in the fertile Piedmont section of South Carolina along the foothills of the Blue Ridge Mountains. The rolling terrain in and around Spartanburg is conducive to good air movement and dispersal characteristics. The crest line of the Blue Ridge Mountains is about fifty miles northwest of the city. These mountains act to some extent as a barrier and sheltering agent for the wind. Elevations within the city range from 800 to 900 ft. above sea level.

Climate

Spartanburg has a mild climate the year round. The average

annual temperature is 61°F, ranging from an average of 42°F in the winter to 71°F in the summer. The area receives approximately 47 inches of precipitation per year with no unusually wet or dry season.[3/]

Low-Level Atmospheric Inversions

Low-level atmospheric temperature inversion conditions develop when the air near the ground is cooled by contact with the earth, while the air aloft stays relatively warm. The stable condition, with the dense cold air at low-level and the lighter warm air above, prevents upward currents and favors accumulation of pollutants near the ground. Precise inversion descriptions require that temperature be measured at more than one elevation above ground. Although such measurements have not been made at Spartanburg, Weather Bureau observers at Memorial Airport have reported typical smoke behaviour indicative of the presence of low-level atmospheric inversions.

When inversion conditions develop, the cooled air near the ground drains into the lower areas of the city. The actual depth of the cold air will vary, depending upon factors affecting its mass, density, and movement. However, the top of the cold air mass has been reported to reach as high as the roofs of some of the larger downtown buildings. The seasonal duration of daylight, cloudiness, fog, or even air pollution

itself, all of which affect the amount of incoming or outgoing thermal radiation, act to control the depth of the cold air layer.

Smoke and other pollutants released within an inversion layer, although originally from a heated source, will rapidly attain the temperature of the surrounding air. Consequently such pollution will not rise through the inversion into the air above. Most of the pollution will rise to the height of the inversion and then will spread out in a pall. At Spartanburg, terrain features and inversion height generally fix this pall at about the level of the top of some of the larger buildings in the business district. It is often possible to look down on the dense pall from the higher elevations within the city and from the airport. With sufficient heating by the sun, surface inversions will break up during daylight hours, and pollution will be diluted and dispersed. However, with the continuous emission of pollutants and with little or no air movement, the highest concentrations of air pollution can be expected when surface inversions do not break up.

A recent compilation of inversion frequencies and analyses of related meteorological parameters delineates geographically and climatologically the percent frequency of low-level atmospheric stability for the United States.[4/] The percent frequency of inversions based at or below five hundred feet above ground level was tabulated

for selected locations. This study indicates that the geographical area composed of northern South Carolina, western North Carolina, and eastern Tennessee, which includes the Spartanburg area, experiences low-level inversions approximately 45 percent of the total hours during the year.[4/] This indicates that the Spartanburg area is subjected to low-level inversions more frequently than most other areas of the United States.

Clear skies and light surface winds at night favor the formation of nocturnal radiation type inversions over land. Areas having a high frequency of inversions are also characterized by a high frequency of relatively clear nights and light winds, and vice versa. On an annual basis the Spartanburg area has a nighttime cloud cover equal to or less than three-tenths 50 percent of the time.[4/] Also the Spartanburg area has nighttime wind speeds equal to or less than 7 miles per hour about 70 percent of the time, on an annual basis. These data further verify that the Spartanburg area is frequently subjected to low-level inversions, a condition that contributes to the accumulation of air pollution.

Stagnating Air Masses

Under the influence of a slow moving or stationary high pressure system stagnant weather conditions may persist over an area for several

consecutive days. During such periods the combination of light wind speeds at the ground and aloft give rise to a low rate of horizontal air movement and restricted vertical mixing. This results in a greatly reduced volume of air into which pollutants are emitted, causing concentrations higher than usual.

The region of the United States east of the Rocky Mountains with the greatest total number of stagnation episodes includes eastern Tennessee, northeastern Georgia, northern South Carolina, and western North Carolina. This particular region, which includes the Spartanburg area, experienced about 279 days of stagnation and 58 stagnation episodes (defined as at least 4 consecutive days of atmospheric stagnation) during the 21 year period 1936-1956.[5/] This indicates an average of 13 stagnation days and about 3 stagnation episodes per year. Such stagnation episodes usually occur during the summer and fall months, with May, October, and November having the highest frequency in the Spartanburg area.

Large scale atmospheric stagnation was responsible for most of the well known disastrous air pollution episodes, such as those of the Meuse Valley, Donora, and greater London. Although the simultaneous occurrence of light and variable winds, great stability in the lower atmosphere, and often fog, is not the usual situation, the persistence of

such conditions for several consecutive days contributes to the accumulation of air pollution.

Winds

Air pollution concentrations generally decrease with increasing wind speeds. However, high wind speeds are not always beneficial. Aerodynamic down-wash of specific stack effluents can bring pollutants to the ground in high concentrations near the stack, when winds are strong. In essence, wind speed and direction data yield an index to the horizontal transport and diffusion of airborne material and thus indicate a rate of ventilation.

Table I shows monthly wind speed and direction data for Spartanburg. Relatively high mean hourly wind speeds occur during the months of March and April and relatively low speeds occur during the months of July and August. The wind speed data were obtained from the U. S. Weather Bureau office at Spartanburg Memorial Airport, about two and one-half miles southwest of downtown Spartanburg. Local topography is such that wind speed data are considered representative for the entire Spartanburg area.

TABLE I
MONTHLY WIND SPEED AND DIRECTION
SPARTANBURG, SOUTH CAROLINA 3/
(1921-1950)

Month	Mean hourly wind speed (mph)	Direction
January	8.6	SW
February	8.9	SW
March	9.8	SW
April	9.4	SW
May	7.8	N
June	7.2	SW
July	6.8	SW
August	6.3	NNE
September	7.3	NNE
October	7.8	N
November	8.1	NE
December	8.1	SW
Year	8.0	SW

SOURCES OF POLLUTANTS

Pollution from Fuel Usage

The combustion of fuel for space and water heating, power generation, industrial processes, and transportation releases pollutants to the atmosphere in the form of gases, solid particulates, and liquid droplets. The type and quantity of pollutants are related to the type of fuel used, condition of firing equipment, firing practices, load demands, and use of air pollution control measures. Fuel usage in Spartanburg (excluding that used in transportation equipment) may be summarized as approximately 72 percent fuel oil, 15 percent coal, and 13 percent natural gas (on a potential BTU basis).

Coal: About 26,000 tons of coal are burned in Spartanburg each year.[67] About 10,000 tons are used for residential heating and 16,000 are used by industrial and commercial establishments. Many of the older residences in the area adjacent to downtown Spartanburg and areas to the south use coal and wood in non-central type heating units and for domestic cooking purposes. These units burn fuel inefficiently, resulting in the discharge of considerable quantities of smoke, particulates, and gaseous pollutants to the atmosphere and in excessive fuel costs.

Many of the commerical and institutional heating installations in Spartanburg use coal for fuel. The discharge of excessive smoke from

most of the commercial and institutional installations is a very common observation. In fact, some installations, such as hotels, office buildings, and colleges, emit dense smoke very frequently. Poor heating plant operation is usually indicated by the emission of dense black smoke.

Most of the coal used in the Spartanburg area is obtained from the fields of West Virginia, Virginia, and Kentucky. These coals usually contain from 20 to 38 percent volatile material, 5 to 8 percent ash, and 0.5 to 1 percent sulfur. This high volatile coal is difficult to burn smokelessly in hand-fired furnaces and all types of poorly designed and operated furnaces. Use of coal with a lower volatile content would aid in the control of smoke in Spartanburg. However, adequate mechanical firing equipment and proper firing practices would also greatly reduce the amount of smoke being discharged to the Spartanburg atmosphere.

Use of coal in mechanically fired furnaces need not cause excessive smoke if proper coal is used in the furnace and good firing practices are followed. However, use of coal in hand-fired furnaces commonly results in excessive smoke because people firing the furnaces do not follow the rather precise procedures necessary to prevent the emission of dense smoke. Although obsolete equipment may be one

factor in the emission of dense smoke it has been found that poorly operated and maintained installations usually create most of the dense smoke.

Coal-fired furnaces will emit ash in appreciable quantities depending on the coal used, firing methods, burning rate, and other factors. In certain large installations ash collecting equipment may be necessary to reduce the emission of ash to the community atmosphere.

Oil: Approximately 24 million gallons of distillate fuel oil and 2 million gallons of heavy residual oil are consumed each year in the Spartanburg area.[6/] Approximately 90 percent of the distillate fuel oil is used for residential heating purposes. The combustion of fuel oil releases formaldehydes, oxides of nitrogen, sulfur oxides, organic materials and some ash to the atmosphere. Although some oil-fired furnaces emit dense smoke, properly maintained and operated oil burners do not produce excessive smoke. It is essential that oil burning equipment be properly adjusted, designed and maintained, and that an appropriate grade of oil be used to insure smokeless operation.

The use of fuel oil in the Spartanburg area is increasing, primarily for space heating in the larger office buildings and commercial installations. Fuel oil consumption in this area does not create a major smoke problem, but it could contribute significantly to such a problem unless

proper surveillance is maintained.

Gas: About 534,400,000 cubic feet of natural gas are used each year in the City of Spartanburg.[7/] Total gas consumption in the Spartanburg area has been increasing substantially each year. This is accounted for by the increased use of gas for domestic space heating, and for commercial and industrial uses. During the summer months (non-heating) approximately 88 percent of the natural gas in the Spartanburg area is consumed by commercial and industrial installations and during the winter months (heating season) approximately 50 percent of the total amount of natural gas is consumed by residential units.

The combustion of natural gas does not produce visible smoke, but does produce gaseous pollutants such as aldehydes, organics, and oxides of nitrogen which add to the total air pollution problem. Increased gas consumption during colder weather indicates that a sizeable proportion of the gas is used for space heating purposes. Maximum gas consumption usually occurs during the month of January and the minimum usually occurs during the month of July.

Gas service is being expanded in the Spartanburg area and it is anticipated that total gas usage will continue to increase in the future. However, the use of natural gas is not expected to produce an appreciable air pollution problem in the Spartanburg area.

Seasonal Variation in Fuel Consumption: The rate of fuel usage is not evenly distributed throughout the year. High usage generally corresponds to the occurrence of colder weather. The use of fuel for heating purposes may be related to the heating degree days (See Table 2). During the five month period, November through March, about 90 percent of the space heating contribution to air pollution will occur.

During the space heating season, the use of coal for heat and power makes a substantial contribution to air pollution problems in Spartanburg, due to the smoke, fly ash, and sulfur dioxide. The combustion of oil and gas for space heating purposes also contributes to the air pollution problem but to a much lesser degree. Occurrence of severe air pollution can be expected during the fall months, the period when stagnating air masses occur most often and when combustion of fuel for heating and power generation purposes is fairly high. However, complaints concerning specific odors and dust conditions are an indication that the combustion of fuels for space heating is not the only source of air pollution in Spartanburg.

Pollution from Transportation

Motor Vehicles: Motor vehicles are considered a significant

TABLE 2
NORMAL HEATING DEGREE DAYS FOR SPARTANBURG, SOUTH CAROLINA 3/
(65° F. base)
(1921 - 1950)

Month	Heating degree days	Percent of total
January	670	22.0
February	549	18.0
March	436	14.2
April	152	5.0
May	26	0.9
June	0	0
July	0	0
August	0	0
September	7	0.2
October	136	4.5
November	414	13.7
December	654	21.5
Year	3,044	100.0

source of air pollution in many communities throughout the country. Motor vehicles discharge significant quantities of hydrocarbons, carbon monoxide, and nitrogen oxides and relatively smaller quantities of aerosols, oxides of sulfur, aldehydes, ammonia, organic acids, and other organic compounds. Gasoline additives, such as tetra-ethyl lead, and motor oil and its additives may also cause air pollution.

Approximately 55,000 autos, trucks, and buses are registered in Spartanburg County.[6/] Approximately 18,000 autos, trucks, and buses are registered and operated by people living in the Spartanburg city limits. Approximately 20 million gallons of gasoline are consumed in the Spartanburg area each year.[6/] Emissions from motor vehicles must be considered a significant portion of the total air pollution load in Spartanburg. However, information available at present does not indicate that regulatory measures are necessary, aside, perhaps from control of excessive visible smoke.

Even though approximately two-thirds of the motor vehicles are registered outside the city they often contribute to the air pollution problem in the metropolitan area. Because Spartanburg serves as a regional shopping center many of the automobiles in the county contribute to the congested traffic situation and the air pollution problem in the City of Spartanburg. In addition to the local traffic, cross country

motor vehicle traffic passes through or adjacent to Spartanburg on transcontinental highways.

A visit to Spartanburg on a Friday evening when the stores are open provides adequate evidence of the congested traffic situation, and of the pungent odors and other air pollution emissions arising from motor vehicles.

Railroads: The Spartanburg area is served by the Southern, Atlantic, Coastline, Clinchfield, and Piedmont and Northern Railroads. All of these railroads use diesel power. Emissions to the atmosphere from diesel engines include hydrocarbons, aldehydes, nitrogen oxides, organic acids, oxides of sulfur, smoke, and other pollutants. A diesel locomotive unit burns about 2 gallons of diesel fuel oil per mile and 3 or 4 of these units are usually required on each freight train. Diesel switch units burn about 8 gallons of fuel per locomotive yard-hour. Considering the fact that Spartanburg does not have extensive railroad switching yards and most railroad service is of the through type, total emissions from railroads in the Spartanburg area are considered to be a minor source of air pollution.

Airlines: The Spartanburg area is served by Eastern and Southern Airlines. The Municipal Airport is located on the rolling plains about

2-1/2 miles southwest of the city. Emission of pollutants from airline activity is not considered significant in the Spartanburg area. Upon completion of the new jet airport located about 20 miles west of the city of Spartanburg the entire operation will be transferred to this new facility in late 1962. It is not expected that the expanded operations at the combined Spartanburg-Greenville jet airport will contribute a significant amount of air pollution.

Industrial Pollution Sources

Industrial processes contribute significant emissions to the air pollution problem in Spartanburg. The following discussion is of a general nature but does enumerate typical emissions that should be considered with the type of industries in Spartanburg.

Textile Mills: The primary air pollution emissions from textile mills result from combustion of fuel for generation of heat and power. Although lint, dust and fine particulate material may be associated with the textile industry, these are normally confined to the in-plant area and therefore, not considered a significant contribution to the community air pollution problem in Spartanburg.

Foundries: Large quantities of air pollutants are emitted to the atmosphere from grey iron foundries unless effective control devices are used. Coarse particulate material may be deposited in the neighborhood of the plant. In addition, smoke, metalic fumes and other air

pollutants may be disseminated into the atmosphere. Formaldehyde and organic binder fumes may be released during molding and mold baking operations. Organics, sulfur dioxide, nitrogen oxide, and carbon monoxide are some of the gaseous air pollutants that are usually emitted during metal melting operations.

Fertilizer Manufacture: Sulfur dioxide and particulate material are some of the pollutants commonly associated with the manufacture of fertilizer. While prevailing winds may often dissipate the emission without creating a nuisance, adverse wind conditions may tend to concentrate the pollutants in some residential areas of the city. Such adverse conditions exist from time to time in Spartanburg and complaints have been made regarding sulfur dioxide and other odors from the fertilizer plant located southwest of the city.

Paper Box and Paper Bag Manufacturing: The fabrication of paper boxes and bags, even though it is a sizeable operation, is not considered a significant source of air pollution.

Lumber Processing: Lumber processing and wood working plants may emit saw dust, spray paint mist, odors from creosote treatment processes, smoke, and fly ash. Smoke and fly ash emissions usually result from the burning of waste wood products in tepee burners.

Animal Feed and Flour Milling: The cleaning and milling of grain for the production of animal feed and flour usually results in air pollution emissions such as fine particulate material, odors, and fumes. The odors are normally associated with the use of additives such as soy bean material, fish meal, and tankage products that are used in the manufacture of certain types of animal feed. The feed mill operation in Spartanburg produces a very significant odor, especially when soy bean material is being processed as a part of the animal feed production. Emission of particulate material is also very evident from this operation.

Miscellaneous Air Pollution Emissions: Solvents are vented to the atmosphere by a multitude of service trades, commercial operations and industries. These add a significant amount of hydrocarbons to the total air pollution problem. Painting, printing, and dry cleaning are among the operations that emit solvents. In addition, the storage and handling of gasoline results in emission of a significant amount of hydrocarbons to the atmosphere.

Pollution from Waste Disposal Operations

Refuse Disposal: The method of refuse disposal is an important factor in controlling air pollution. In Spartanburg, practically all of the refuse is disposed of at a sanitary landfill and there is very little back-

yard burning. Open burning of brush and tree trimmings along with demolition waste materials is practiced occasionally. In view of this, refuse disposal is not considered a major source of air pollution in Spartanburg. However, consideration should be given to the type of incinerators installed at apartment houses and at commercial and industrial installations. Single chamber incinerators (the type normally used in apartment houses and at commercial and industrial installations) are known to contribute to the smoke and fly ash problems such as Spartanburg experiences. Studies have shown that single chamber incinerators emit almost ten times more particulate material per ton of refuse burned than multi-chamber type incinerators. Single chamber incinerators are also more likely to cause odor problems than are multiple chamber incinerators. In view of this, it is felt that multi-chamber incinerators, comparable in design to those that have been so effective in Los Angeles, should be required for all new apartment houses, commercial and industrial incinerator installations. This would greatly reduce the amount of air pollution due to refuse disposal.

Sewage: Sewage from Spartanburg is collected and treated at a plant located southeast of the city. There have been no odor complaints from this operation and no evidence that it contributes significantly to the air pollution problem.

PAST INVESTIGATIONS

In 1954, the Chamber of Commerce arranged for a survey to be made by the Coal Producers Committee for Smoke Abatement. This survey provided consultative engineering service concerned with the efficient use of solid fuel and made recommendations for the reduction of dense smoke and fly ash. This survey covered 39 installations, including 16 public schools, 22 commercial and industrial installations, and one college.[8/] The resulting report indicated that most of the commercial and industrial plants had fuel burning equipment that was poorly operated and maintained and this was a significant factor in the emission of dense smoke from these installations. This report also pointed out that about 20 percent of the plants were considered obsolete; about 25 percent of the plants were considered overloaded; and about 38 percent of the equipment was not considered adequate or correctly installed. This report also indicated that improper operation, lack of maintenance and poor housekeeping were noted in most of the commercial and industrial fuel burning installations. Specific recommendations were provided for the abatement of smoke to reasonable levels and pointed out that proper operation and maintenance of these installations would reduce both fuel costs and dense smoke emission.

AIR POLLUTION MEASUREMENTS

Conduct of the Study

The study was planned to provide air pollution measurements for seven days, February 15-21, including one weekend and one all-night sampling period. Except for the all-night sampling period, samples were collected between 8:00 a.m. and 5:00 p.m. Gaseous and particulate pollutants measured are indicative of the general levels of air pollution. Visibility determinations to ground level objects were taken to indicate the general presence of particulate pollutants. Sampling was done on top of the Spartanburg City Hall, about twenty-five feet above ground level.

Measurements were made of total oxidant, nitric oxide, nitrogen dioxide, carbon monoxide, sulfur dioxide, hydrogen sulfide, and particulate matter. Gaseous pollutants were sampled by drawing outdoor air at measured rates through liquid chemical solutions or chemically impregnated granules or filter paper tape. Illustration 1 shows part of the sampling equipment used during the study. Samples for total oxidant were collected for ten minute periods each hour and samples for nitric oxide, nitrogen dioxide, carbon monoxide, and sulfur dioxide were collected for thirty minute periods every two hours. Hydrogen sulfide was measured with a filter paper tape sampler that draws a metered amount of outside air (about 0.25 CFM) through a lead acetate

impregnated filter paper. The sampler was operated continuously, using a one hour period for each sample. Soiling capacity was measured with an AISI sampler that draws a metered amount (about 0.2 CFM) of outside air through a strip of filter paper. The sampler was operated continuously using a three hour period for each sample. The hydrogen sulfide and AISI filter papers were evaluated with a photoelectric device for measuring light transmittance through the filter papers. Suspended particulate matter was collected by a high volume sampler, which draws outside air through an 8 x 10 inch fiber glass filter. These samples were collected for 24-hour periods. Illustration 2 shows both a clean and exposed fiber glass filter paper used during the study and Illustration 3 shows the soiling capacity sampler.

Results of Measurements

Table 3 lists the maximum levels of pollution found during the study period. (See Appendix)

Total oxidant, nitrogen dioxide, and nitric oxide, (considered indicators of photochemical smog of the Los Angeles type) were not found in concentrations which indicate the presence of Los Angeles type smog during the study period. The maximum level of 0.08 ppm for sulfur dioxide is not considered an indication of a serious air pollution problem. The maximum level of hydrogen sulfide found during the study was beneath the detectable

level of odor perception, 0.02 ppm on an hourly average basis. The carbon monoxide levels observed are not considered an indication of a serious air pollution problem.

It should be recognized that a combination of adverse meteorological conditions, such as low wind speed and an atmospheric temperature inversion, could cause these pollutants to accumulate to levels several times higher than those observed during the study. During other air sampling studies when adverse meteorological conditions have persisted, pollutant levels comparable to these have doubled or tripled in a matter of two or three hours.

Table 4 gives the soiling capacity results for the respective three hour periods during the seven-day study period. The levels reached a general peak during the 6 a.m. to noon period. This period coincides with the heavy motor vehicle traffic, the heating period for industrial, commercial and residential fuel burning facilities, and the usual strong early morning atmospheric temperature inversions. The levels fall to a minimum during the middle part of the day when atmospheric dispersion is the greatest and then to rise to a secondary peak in the evening due to the onset of atmospheric temperature inversion conditions.

Table 5 gives the AISI smoke measurement results classified according to a system devised by the New Jersey State Health Department. 9/

From this classification it can be seen that during the seven-day study, the Spartanburg air contained smoke concentrations in the heavy, very heavy, or extremely heavy category about 75 percent of the time, even though the meteorological conditions during this period were very favorable to dispersal of smoke and other air pollution. In similar studies the maximum concentrations found were 5.5 Cohs/1000 linear feet in Washington, D. C.; 5.1 in Lynchburg, Virginia; and 8.0 in Richmond, Virginia. The 6.7 Cohs/1000 linear feet maximum found in Spartanburg exceeds the levels found in some of the above listed cities which are generally more highly industrialized or larger population centers.

The California standard for particulate matter in the air classifies the situation as "adverse" when visibility is reduced to less than three miles when relative humidity is less than 70 percent. This particular standard was exceeded in Spartanburg on three of the seven days covered by the sampling period. A large portion of the particulate material, which is primarily responsible for the visibility reduction, appeared to be from smoky fuel burning installations.

Levels of suspended particulate matter, as indicated by high volume filter paper sampling, were not found to be particularly high.

However, they are comparable to average levels found in Lynchburg, Richmond, Washington, and Atlanta, all large population centers or industrialized areas. For a city of its size, Spartanburg has a relatively high level of particulate pollution.

Figures 1 and 2 show the variations of maximum levels of certain gaseous and particulate pollutants together with the average daily wind speed. In general, pollution levels for both gaseous and particulate pollutants increased with a decrease in the average daily wind speed. Maximum pollutant levels occurred on the day of minimum average daily wind speed and minimum pollutant levels occurred on the day of maximum daily wind speed. The combination of adverse meteorological conditions (low-level temperature inversion and an extended period with practically no wind) caused air pollution to accumulate during the morning of February 17. During this period a definite visible pall existed over the Spartanburg area and practically all of the pollutant levels increased significantly. Although these adverse meteorological conditions only existed for a short time, practically all of the maximum pollution levels found during the seven-day study occurred during this period. The situation in Spartanburg on the morning of February 17,

with reduced visibility and a definite visible pall, was typical of those that have been observed in other studies when pollution levels have been high. About mid-morning on February 17, the wind speed increased significantly and the low-level temperature inversion broke up. This change in meteorological conditions favored the dispersal of air pollution. Therefore, the levels obtained after the change were only about one-half what they had been during the peak period two hours earlier.

Table 6 gives selected meteorological data for the Spartanburg area for the period of February 15-21, 1962. The average daily wind speeds and the amount of precipitation indicate that during February 16, 18, 20, and 21 the weather was generally unstable (stormy and windy), a condition which favored the dispersal of air pollution rather than its accumulation. Therefore, in general, the pollution levels found during the study are probably lower than would be expected during periods when the meteorological conditions were less favorable for air pollution dispersal.

The levels found for the gaseous pollutants do not indicate the presence of a serious air pollution problem; however, it must be realized that these levels were obtained during a period when the

meteorological conditions were generally favorable to air pollution dispersal rather than its accumulation. Total oxidant, nitrogen dioxide, and nitric oxide (considered indicators of photochemical smog of the Los Angeles type) were not found in concentrations which indicate the presence of Los Angeles type smog during the study period. However, it should be realized that a combination of adverse meteorological conditions such as low wind speed and a low-level temperature inversion could cause all of the gaseous pollutants to accumulate to levels several times higher than those observed during the study.

The high levels found for soiling capacity and particulate matter and the occurrence of reduced visibility indicate a general smoke problem and the presence of other activities which discharge particulate material to the atmosphere. Even though the weather favored the dispersal of air pollution, the maximum levels found for soiling capacity and particulate matter are comparable to levels normally found in more industrialized areas and in larger population centers.

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4. Hosler, Charles R., "Low-Level Inversion Frequency in the Contiguous United States", Monthly Weather Review, 89, 319-339, September 1961.

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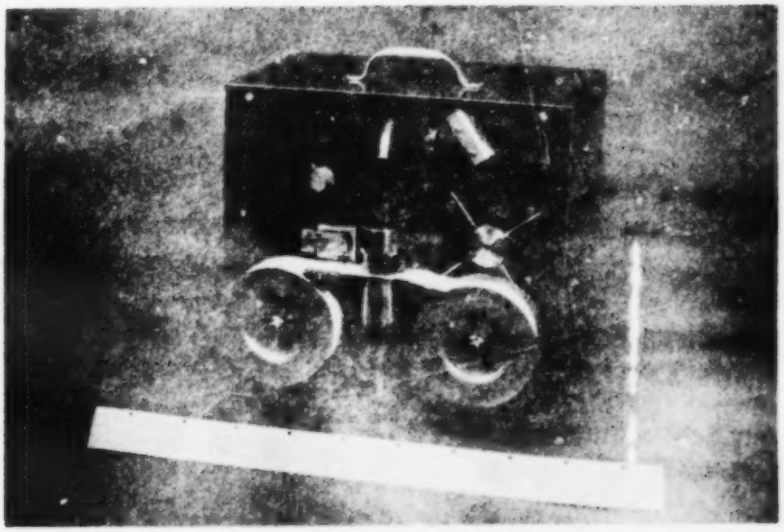
Illustration No. 1
Part of the Sampling
Equipment used.

Illustration No. 2
High Volume Sampler
with new filter paper
and one exposed for
24-hour sampling period.

Illustration No. 3
Soiling
Sampler



APPENDIX

Results of Air Pollution Measurements

TABLE 3

MAXIMUM POLLUTION LEVELS
SPARTANBURG, SOUTH CAROLINA
FEBRUARY 15-21, 1962

Day & Date	Oxidant ppm	Sulfur dioxide ppm	Nitrogen dioxide ppm	Nitric oxide ppm	Carbon monoxide ppm	Hydrogen* sulfide ppm	Soiling capacity Cohs/1000	Particulate material** ug/m^3	Lowest visibility when rel. hum. less than 70% ***	
									Visib. (miles)	Rel. hum. (percent)
Feb. 15, Thursday	0.10	0.03	0.02	0.03	1.7	0.005	3.7	92	1.5	57
Feb. 16, Friday	0.06	0.03	0.04	0.05	0.8	0.007	4.8	101	———	
Feb. 17, Saturday	0.10	0.07	0.06	0.06	1.25	0.013	6.7	123	1.5	63
Feb. 18, Sunday	0.07	0.08	0.04	0.02	0.8	0.005	4.5	117	———	
Feb. 19, Monday	0.07	0.03	0.05	0.01	1.25	0.006	5.4	85	———	
Feb. 20, Tuesday	0.06	0.02	0.06	0.02	0.8	0.004	4.5	76	———	
Feb. 21, Wednesday	0.05	0.03	0.04	0.02	0.5	0.006	5.4	108	2.0	65

* Estimated

** Particulate concentrations are reported for the day on which the sampling was completed. (Sampling Period from 4:00 p.m. to 4:00 p.m.)

*** Visibility observations made from air sampling station on top of Spartanburg City Hall.

TABLE 4

SOILING CAPACITY RESULTS
SPARTANBURG, SOUTH CAROLINA
FEBRUARY 15-21, 1962
(Readings in Cohs/1000 Linear Feet)

Date	12-3 a.m.	3-6 a.m.	6-9 a.m.	9-12 a.m.	12-3 p.m.	3-6 p.m.	6-9 p.m.	9-12 p.m.	Average
Thur. Feb. 15	1.8	3.7	3.3	2.3	1.3	2.0	3.7	2.5	2.6
Fri. Feb. 16	1.6	1.8	*	3.8	2.2	2.0	4.8	3.9	2.9
Sat. Feb. 17	4.7	3.3	6.7	*	1.5	1.6	3.3	3.3	3.5
Sun. Feb. 18	4.0	2.6	4.5	2.7	2.5	2.8	2.5	2.2	3.0
Mon. Feb. 19	1.6	2.0	5.4	4.3	1.8	1.5	2.1	1.8	2.6
Tue. Feb. 20	1.5	1.5	2.3	2.0	1.3	1.8	4.5	2.9	2.2
Wed. Feb. 21	2.5	2.7	4.8	5.4	2.9	3.6	3.3	3.3	3.6
Average	2.5	2.5	4.5	3.4	1.9	2.2	3.5	2.8	

* Periods when the sampler was inoperative.

TABLE 5

SOILING INDEX CLASSIFICATION
SPARTANBURG, SOUTH CAROLINA
FEBRUARY 15-21, 1962

Soiling Unit Range Cohs/1000 Linear Feet	Description	Number of 3 hr. periods	Percent of Total
0.0 to 0.9	Light	0	0
1.0 to 1.9	Moderate	14	25.8
2.0 to 2.9	Heavy	19	35.2
3.0 to 3.9	Very Heavy	11	20.5
4.0 and over	Extremely Heavy	10	18.5
	Total	54	100.0

TABLE 6

METEOROLOGICAL DATA
SPARTANBURG, SOUTH CAROLINA
FEBRUARY 15-21, 1962

Date	Max. Temp. °F	Min. Temp. °F	Wind			Precipitation inches	% Relative Humidity	
			Ave. Speed mph	Max. Speed mph	Direction of Max. Speed		Max.	Min.
Thursday, Feb. 15	59	39	7.0	16	NW	0	59	29
Friday, Feb. 16	52	34	6.5	11.5	NNE	0.54	100	55
Saturday, Feb. 17	56	29	3.8	9.2	SSE	0	100	54
Sunday, Feb. 18	45	34	6.7	13.8	NNE	0.39	100	80
Monday, Feb. 19	57	42	8.1	16	SW	T	100	31
Tuesday, Feb. 20	62	39	11.6	23	NNW	0	60	22
Wednesday, Feb. 21	45	38	5.6	15	NNE	0.32	100	47

* Data from U.S. Weather Bureau Station, Spartanburg, Memorial Airport

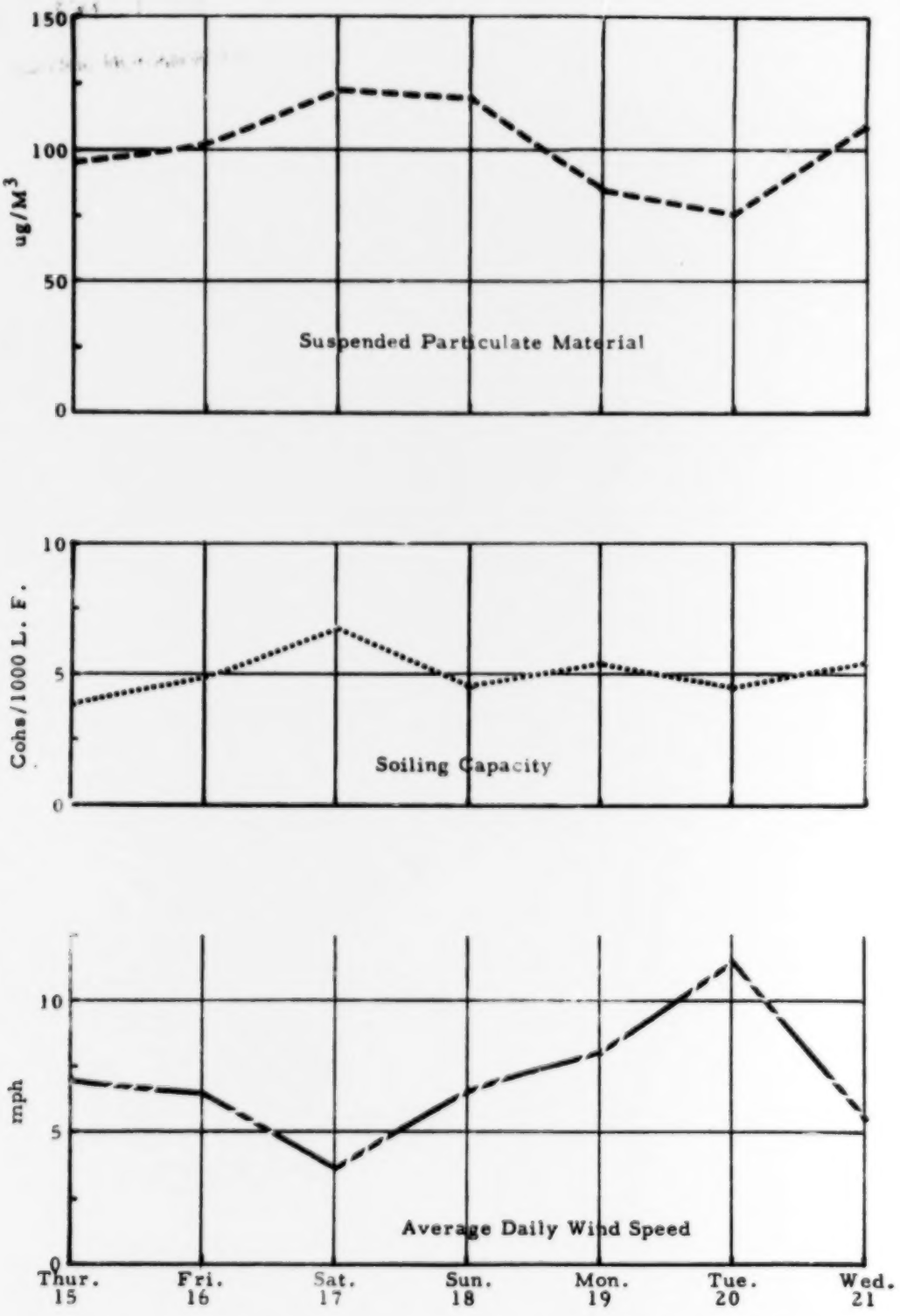


Figure 1. Daily Maximum Levels for Suspended Particulate and Soiling Capacity with Average Daily Wind Speed